

## ?igWXY`b`a]h`@]hh`Y`xXY.`9bhgdUbbib[`ZØf ?cV`YbnYf`GhiX]YfYbXY`]b`XYf DfØZib[gnY]h

± ?cV`Ybn`\]`Zh`XYf`dÀXU[c[]gWXY`6Y[`Y]h\ibX'/eich/@]hh`Y ∞Y/eich/GhiX]YfYbXYbž`ghfYgg][Y`DfØZib[gd\UgYb`ni VYkÀ`h][Yb"'?igWXY`b`U`g`9bhgdUbbib[gaU»bU\aY°

± XYf`\Y\_h]gWXYb`DfØZ b[gnY]h`\UVYb`j]Y`Y`Ghi X]YfYbXY`a]h Yf\YV`]WXYa`GhfYgg`ni`\_ÀadZYb"`Ia`X]YgYa`DfcV`Ya`ni VY[Y[bYbž`\Uh`XUg`@UbXYgV]V`]ch\Y\_gnYbhfia`]b`?cV`Ybn`Y]b]bbcjUh]jYg`?cbnYdh`jcf[YghY``h`XUg`?igWXY`b`a]h`XYadÀXU[c[]gWXYb`6Y[`Y]h\ibX`@]hh`Y`≈Y "'8Ug`DfcY\_h`a]h`XYaBUaYb`@YfbdUigY`a]h`DZÒhWXYb`V]YhYh`Y]bY`YbhgdUbbYbXY5iqnY]h`ZØf`X]Y`Ghi X]YfYbXYb"

8 Yf'GhfYggž'XYf'cZh'a ]h'DfØZi b[Yb'j YfVi bXYb']ghž'\_Ubb'X]Y?cbnYbhfUh]cb'i bX'XUg'U``[Ya Y]bY'K c\`VYZ]bXYb

VYY]bhfÀW\h][Yb"'\D'?cV`Ybn'\UVYb'JYfUbhk cfh`]W\Y'X]YgYb'Di b\_h

Yf\_Ubbhii bX'Y]bY'@Ògi b[']bg'@YVYb'[Yfi ZYbž'X]Y'Ui Z

k ]ggYbgW\UZh`]W\Yb'9f\_Ybbhb]ggYb'VUg]Yfh"'< Ubg!9f]W\'5i ž'XYf

DfYggYgdfYW\Yf'XYg'@UbXYgV]V`]ch\Y\_gnYbhfi a g'F\Y]b`UbX!DZU`nž

Yf\_`Afh' K ]Y'k ]f'Ui g'XYf'K ]ggYbgW\UZh'k ]ggYbž'g]bX'[YfUXY'H]YfY

XU'VYgcbXYfg'[YY][bYh" '8]Y'\DhYfU\_h]cb'a ]h'H]YfYb'\_Ubb'XUVY]

\Y`ZYbž'GhfYgg'UVni VUi Yb'i bX'X]Y'Gh]a a i b['ni '\YVYb"

## ?igWXY`b`a]h`@]hh`Y`xXY `U`g GhfYggVYk À`h][ib[

 $8 \ Yf' \ Z\emptysetb \ Z'A \ f][\ Y'A \ ]gWX`]b[' @]hh`Y' x Y \ ghY \ h'XYb' Ghi X]YfYb XYb']b$   $Y]bYa \ gdYn]Y``Yb'FUi a \ 'ni f' \ YfZ\emptyset[i b[ \ z'XYf' \ Z\emptysetf' 9bhgd \ Ubbi b[' i b X \ Gd]Y`[ \ YghU`hi b[ \ 'Y]b[ \ Yf]WXhYh']gh'' < ]Yf' _ ObbYb' X]Y' HY]`bY \ a \ Yf'a ]h$ 

XYa '<i bX'\_i gW\Y`bž'Hf]W\_g'ØVYb'cXYf'Y]bYb'\_`Y]bYb'DUf\_ci f
UVgc`j ]YfYb"'8]Y'<i bXYVYg]hnYf]bž'?Yfgh]b'<Y]bf]W\ž'\Uh' @]hh`Y

£Y 'Ui g'XYa 'H]YfgW\i hn'UXcdh]Yfh'i bX']\b'j cf'nk Y]'\\\\\fYb
Ui g[YV]`XYh"'G]Y'VYgW\fY]Vh'X]Y'G]hni b[Yb'U`g'Y]bY'`]YVYj c``Y
A Ò[`]W\\_Y]h'ZØf'X]Y'Ghi X]YfYbXYbž'GhfYgg'UVni VUi Yb.' 8]Yž'X]Y
XUfUb'hY]`bY\a Ybž'[Y\Yb'Ui W\'U``Y'a ]h'Y]bYa '[Ubn'X]\\\_Yb
@ÀW\Y`b'\]Yf'k ]YXYf'fUi g" '<Y]bf]W\'VYhcbh'YXcW\'Ui W\\ž'XUgg'g]Y
g]W\YfghY``hž'XUgg'Yg' @]hh`Y'\&Y' [i h'[Y\h'i bX'Yf'g]W\'k c\`ZØ\`h"

 $8 ] Y'6Y'] YVh Y] h'j cb' @] hh'Y' x Y' ] gh'i b Ø VYfgY VUf'' 9g'k ] f X'gY f [i h'Ub[Ybca a Yb ž'VYf] W hYh' < Ubg! 9f] W '5i "'I b X'Y] b Y'Ghi XYbh] b ZØ [h'\] bni .' 8 Yf' < i b X'] gh'\ U'h'g W cb'i bg W `U[VUf'g Ø \sigma "'Gc`W Y dcg] h] j Yb'F Ø W_a Y`Xi b [Yb'nY] [Ybž'k] Y'k Yfhj c``'X Ug'D f c Y_h'Z Ø f j ] Y'Y'] gh'' @] hh`Y' x Y'gY`Vgh'g W Y] bh'X] Y'NY] h'a ] h'XYb'Ghi X] YfYb XYb YVYb ZU``g'ni '[Yb] Y \sigma Yb''GY] b Y'J cf'] YVY'[]`h'VYg cb XYfg'X Ya? i g W Y`b'VY] k Ufa Ya'K YhhYf'i b X'XYb'j ] Y`Yb'@ Y W_Yf`] g ž'X] Y'Yf'Z Ø f g Y] b Y'Hf] W_g'Yf \A`h''$ 

## $5i gV^{Ui} Z^{ni} _\emptyset bZh][Y^Dfc^Y_hY]$

K À\fYbX'XUg'?i gWXY`b'a ]h'<i bXYb']b'?cV`Ybn'Y]b'bYi Yg?cbnYdh'XUfghY``hž'[]Vh'Yg']b'F\Y]b`UbX!DZU`n'Ui WX'D`ÀbY'ZØf
À\b`]WXY'\D]h]Uh]j Yb"'5b'XYf'\&\UbbYg'; i hYbVYf['I b]j Yfg]hÀh']b
A U]bn'gc```]a '\J\f'&\\$\) 'Y]b'D]`chdfc'Y\_h'ghUfhYbž'XUgg'g]WX'a ]h'XYf
GhfYggVYk À`h][i b['Xi fWX'H]YfY'VYgWX\AZh][h''@Ui h'Y]bYf'GdfYWXYf]b
k YfXYb'ni fnY]h'Yhk U'\&) '?i fgY'dfc'GYa YghYf'Ub[YVchYbž'X]Y'a ]h
9bhgdUbbi b[ghYWXb]\_Yb'i bX'GhfYgga UbU[Ya Ybh'ZØf'Ghi X]YfYbXY
ni 'hi b'\UVYb"'8]Y'\DhY[fUh]cb'j cb'gc[YbUbbhYb' 7UfY'8c[g'i bX'FYUX]b['8c[g'i k]fX'U`g'b\AW\ghYf'GWXf]hh'[YgY\Ybži a 'XYb
Ghi X]YfYbXYb'VY]'XYf'6Yk \A`h][i b['j cb'GhfYgg'i bX'XYf'5b[ghž'j cf'; fi ddYb'ni 'qdfYWXYbž'ni '\Y`ZYb"

±g[YgUa hinY][YbiDfcY\_hYik]Yi @YfbdUi gYia]hiDZÒhWkYb žik]YH]YfYiYfZci[fY]Wki]biGhfYggVYkÀih][ib[ga U»bU\a Ybi]bhY[f]YfhkYfXYbi\_ÒbbYb"i8]Yidcg]h]jYiFYgcbUbniXYfiGhiX]YfYbXYbi]b?cViYbni\_ÒbbhYiU`giAcXY``ZØfiUbXYfYi<cWkgWkiiYbiX]YbYb"i±bY]bYfiNY]hži]biXYfiXYfi8fiW\_iUiZiGhiX]YfYbXYi\cWki]ghžiV]YhYbgc`WkYi±b]h]Uh]jYbiY]bYik]``\_ca a YbYiAÒ[`]Wk\_Y]hži9bhgdUbbib[

i bX:: fYi XY']b'XYb'cZh'\Y\_h]gW\Yb'Ghi X]YbU``hU[ 'ni 'Vf]b[ Yb"'8 Ug
H\Ya U'GhfYggVYk À`h][ i b[ 'V`Y]Vh'Y]b'GW\`ØggY`ZU\_hcf'ZØf'X]Y
; Ygi bX\Y]h'i bX'XUg'U\_UXYa ]gW\Y'K c\`VYZ]bXYb''^i b[ Yf
A YbgW\Yb"

#D'XYb'`YhnhYb'\*J\fYb'\Uh'XUg'6Yk i gghgY]b'ZØf'X]Y'5i gk]f\_i b[Yb j cb'GhfYgg'Ui Z'X]Y'dgmW\]gW\Y'i bX'd\mg]gW\Y'; Ygi bX\Y]h'j cb Ghi X]YfYbXYb'ni [Ybca a Yb'''GhfYgg']b'DfØZi b[gd\UgYb'\_Ubb'ni Yfbgh\UZhYb'DfcV'Ya Yb'k]Y'6i fbci h'ZØ\fYbž'i bX'XU\Yf'g]bX ]bbcj Uh]j Y'5bgÀhnY'ni f'GhfYggVYk À`h][i b['\]Yf'j cb'[fc\*Yf6YXYi hi b["'8Ug'Dfc'Y\_h' @YfbdUi gY'a]h'DZÒhW\Yb ']b'?cV`Ybn']gh Y]b'VYgcf[b]gYffY[YbXYg'6Y]gd]Y``ZØf'bYi Y'#bhYfj Ybh]cbYbž'X]Y Ui Z'X]Y': ÒfXYfi b['XYg'K c\`VYZ]bXYbg'j cb'Ghi X]YfYbXYb UVn]Y`Yb"

 $= \exists \exists \forall Yf[\ `Y]W\ `ni \ `hfUX]h]cbY``Yb`AYh\cXYb`XYf`GhfYggVYk A`h][\ ib[\ \check{z}\ k]Y`Yhk U`XYf`AYX]hUh]cb`cXYf`Mc[Už`V]YhYh`XUg`Ni gUa aYbgY]b a]hY]bYa`<ibX`Y]bYi ba]hhY`VUfY`Yach]cbU`Y`JYfV]bXi b[":cfgWXi b[gghi X]Yb`\UVYb`[YnY][hž`XUgg`XYf`?cbhU_h`ni `H]YfYb XUg`GhfYgg\cfacb`7cfh]gc``fYXi n]YfYb`_Ubb`i bX`X]Y 5i ggWX Øhhi b['jcb`GYfchcb]b`i bX`8cdUa]b`ZÒfXYfhž`X]Y`ZØf; `ØW_g[YZØ\`Y'jYfUbhk cfh`]WX`g]bX"`Gc`WXY`9f[YVb]ggYi bhYfghØhnYb`X]Y`\XYY'j cb`h]Yf[YghØhnhYb`H\YfUd]Yb`U`g`k]f_gUaY5`hYfbUh]jYb`ni f`GhfYggVYk A`h][i b["'@Ui h`Y]bYf`I bhYfgi WXi b[`XYf5aYf]WUb`DgmWXc`c[]WU``5ggcW]Uh]cb`\UVYb`GWXØ`Yfž`X]YfY[Y`a A`x][`NY]h`a]h`H]YfYb`jYfVf]b[Ybž'b]YXf][YfY`GhfYgg`YjY`i bX`VYf]WXhYb'jcb`Y]bYa`[YghY][YfhYb`; YZØ\``XYg K c\`VYZ]bXYbg"$ 

## $8 Ug^{\circ}? cbnYdh^{\circ}XYf^{\circ}h]Yf[Ygh\emptysethnhYb^{\circ}H\YfUd]Y$

8]Y'JYfk YbXi b['j cb'H]YfYb'ni f'I bhYfghØhni b['XYf'dgmWk]gWkYb; Ygi bX\Y]h']gh'b]Wkh'bYi "'8]Y'h]Yf[YghØhnhY'H\YfUd]Y'\Uh']b'XYf DgmWkc`c[]Y'i bX'Gcn]U`UfVY]h'Ub'6YXYi hi b['[Yk cbbYb"6YgcbXYfg'VY]'XYf'5fVY]h'a]h'hfUi a Uh]g]YfhYb'\DX]j ]Xi Yb'cXYf']b XYf'DÀX]Uhf]Y'k i fXYb'dcg]h]j Y'9ZZY\_hY'ZYgh[YghY``h"'H]Yf[YghØhnhY\DAX]Uhf]Y'k i fXYb'dcg]h]j Y'9ZZY\_hY'ZYgh[YghY``h"'H]Yf[YghØhnhY\DhYf] Ybh]cbYb'\_ObbYb'j YfgWk]YXYbY': cfa Yb'UbbY\a Ybž'j cb 6Ygi Wkgdfc[fUa a Yb']b'9]bf]Wkhi b[Yb'V]g'\]b'ni

6]`Xi b[gdfc^Y\_hYb^k]Y`XYa `]b`?cV`Ybn"`8i fW\XX]Y`?ca V]bUh]cb j cb`@YfbYb`i bX`±bhYfU\_h]cb`a ]h`Y]bYa `h]Yf]gW\Yb`6Y[`Y]hYf`k]fX Y]bY`YbhgdUbbhY`5ha cgd\ÀfY`[YgW\UZZYbžX]Y`XUg`@YfbYb`ZÒfXYfh"

9]b 'À\b`]W\Yg'Dfc Y\_hž'XUg'dcg]h]j Y'F ØW\_a Y`Xi b[Yb'Yf\]Y`hž']gh XUg'XYf'HYW\b]gW\Yb'<cW\gW\i `Y'8Y[[YbXcfZ\*k c Ghi X]YfYbXY'YVYbZU``g'X]Y'A Ò[`]W\\_Y]h'\UVYbž'a ]h'<i bXYb'ni UfVY]hYbž'i a 'GhfYgg'UVni VUi Yb"'Gc`W\Y'Dfc[fUa a Y'nY][Ybž'XUgg X]Y'6YXØfZb]ggY'XYf'Ghi X]YfYbXYb'Ui Z']a a Yf'j ]Y`ZÀ`h][YfY'K Y]gY Ub[YgdfcW\Yb'k YfXYb'gc``hYbž'i a 'X]Y'; Ygi bX\Y]h'i bX'XUg K c\`VYZ]bXYb'k À\fYbX'XYf'cZh'\YfUi gZcfXYfbXYb'Ghi X]YbnY]h'ni ZÒfXYfb"

8 Y hU]`q

6 Ygi WX Yb 'G]Y 'i bg 'Ui Z. 'b!U[ "XY